DOCUMENT RESUME

ED 382 481 SE 056 327

AUTHOR Yager, Robert E.
TITLE Science/Technology/Society: A Reform Arising from Learning Theory and Constructivist Research.
PUB DATE Apr 95
NOTE 20p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Francisco, CA, April 18-22, 1995).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Constructivism (Learning); Educational Change; Intermediate Grades; Junior High Schools; *Learning Theories; *Middle Schools; *Science and Society; Science Education; Science Programs; Student Surveys; *Technology
IDENTIFIERS Iowa; Science Achievement; *Scope and Sequence; Teacher Surveys

ABSTRACT

The Iowa-Scope, Sequence, and Coordination (SS&C) Program assists schools with reform of their entire middle school programs, grades 6-8, and features the science, technology, and society (STS) instructional approach. This reform translates to the creation of new frameworks for the school program and aims to produce "constructivist" teachers to implement the reform. One such program is evaluated by examining improvements in student learning in six learning domains: concept, process, application, creativity, attitude, and world view. Teachers were surveyed to determine changes in teacher confidence, exemplary use of certain teaching procedures, and changes in teacher perceptions of various student attributes. Pre- and posttests were administered to all students of 133 SS&C teachers during 1990-93. A comparison is made between SS&C classrooms and traditional classrooms. Statistically significant advantages were observed for female students as well as average and below average students. The evaluation reveals that the program successfully responds to calls for reform and restructuring of middle school programs. (LZ)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED 382 481

SCIENCE/TECHNOLOGY/SOCIETY: A REFORM ARISING FROM LEARNING THEORY AND CONSTRUCTIVIST RESEARCH

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

X This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

ROBERT YAGER

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)"

Robert E. Yager
Professor, Science Education
Science Education Center
The University of Iowa
769 Van Allen Hall
Iowa City, Iowa 52242-1478

Phone: 319-335-1189
FAX: 319-335-1188

Paper presented at the American Educational Research Association Annual Meeting, San Francisco, California, April 18-22, 1995.

SE054327

SCIENCE/TECHNOLOGY/SOCIETY: A REFORM ARISING FROM LEARNING THEORY AND CONSTRUCTIVIST RESEARCH

Iowa-SS&C is a program designed to assist the staff in local schools to restructure their middle school programs to achieve specific goals, including:

1. Providing an integrated structure for instructional modules in middle schools organized around problems which are local, personal, and relevant to the lives of students;
2. Including traditional content and skills because they are needed to work on the problems and issues identified;
3. Referring to previously used concepts and processes as they are needed in new contexts;
4. Changing teaching behaviors which are needed in constructivist classrooms; and
5. Collecting and analyzing evidence of student learning resulting from the new approaches to curriculum and instruction.

Iowa-SS&C aims to produce "constructivist" teachers to implement the reform; such teachers are characterized as those who:

1. Encourage and accept student autonomy, initiation, and leadership;
2. Allow student thinking to influence or drive lessons;
3. Shift content and instructional strategies based on student responses and preconceptions;
4. Ask students to elaborate on their responses;
5. Allow wait time after asking questions;
6. Encourage students to interact with each other and with the teacher;
7. Ask thoughtful and open-ended questions;
8. Encourage students to reflect on experiences and predict future outcomes;
9. Ask students to articulate their theories about concepts before presenting their own understanding of the concepts; and
10. Look for conceptual meaning their students have and design lessons to address any misconceptions (Yager, 1991).

All of the national reform efforts are defined as changing the goals, curriculum, instructional strategies, and assessment practices which result in significant improvements in student learning and improved teaching practices. Efforts such as the Iowa Chautauqua Program and Iowa-Scope, Sequence, and Coordination (SS&C) can be described as reforms which begin with current issues and often end with attempts to resolve them.

Iowa-SS&C utilizes the STS instructional approach (i.e., the teaching and learning in the context of human experience [NSTA, 1990-1991, p. 47]). Hallmark characteristics of this approach are: student identification of problems/issues with local interest and impact; the use of local resources (human and material) to locate information that can be used in problem resolution; the active involvement of students in seeking information that can be applied to solve real-life problems; the extension of learning beyond the class period, the classroom, the school; a view that content is more than concepts which exist for students to master on tests; an emphasis upon process skills which students can use in resolving their own problems; an emphasis upon career awareness—especially careers related to science, technology, and the social sciences; opportunities for students to experience citizenship roles as they attempt to resolve issues they have identified; identification of ways that science and technology are likely to impact the future; and some autonomy for students in the learning process (as individual issues are identified).

The Iowa-SS&C Program assists schools with reform of their entire middle school programs, Grades 6-8. This reform translates to the creation of new frameworks for the school program. Such frameworks match the features for SS&C, namely a) integrated content (social studies, science, and mathematics, b) important concepts and skills are used multiple times at a given grade level and spaced across grade levels, c) hands-on/minds-on activities are featured, and d) problem-centered materials where the problems are personally and locally relevant. At the same time, the reform relies on changes in teachers. Quite often teachers themselves must learn about constructivist learning and identify teaching strategies which encourage such learning.

Ultimately, the success of such curricular and instructional changes is judged by the successes of students enrolled in SS&C courses. Success with Iowa-SS&C is measured by

improvements in student learning in six learning domains, namely, concept, process, application, creativity, attitude, and world view.

Methods

All teachers, classrooms, and students in the current program come from schools which were included in the 1990-93 SS&C project supported by a $1.3 million grant from the National Science Foundation. This project included four centers (Chariton/Creston, Council Bluffs, Davenport, and Mason City) with five smaller independent districts appended to one or more sites. Most of the teachers used in this study taught only SS&C sections; however, 20 teachers agreed to maintain one or more sections where the textbook was used extensively. This provided us with both experimental and traditional classrooms and students for the study.

All of these teachers were surveyed to determine changes in teacher confidence, exemplary use of certain teaching procedures, changes in teacher perceptions of various student attributes prior to and following SS&C instruction through an analysis of a sampling of video recordings of 15 SS&C and 15 non-SS&C classrooms. Additionally teacher success was measured by action research projects designed to test their ideas about their own teaching. A total of 105 teachers in non-SS&C sites who were fully qualified and who had been enrolled in a special inservice program were invited to serve as a control group. Forty-eight agreed to participate in the study of teaching and teacher participation. Hence they were similar in terms of being teachers in similar schools as the participants and equivalent levels of experience and preparation.

Pre- and posttests were administered to all students of 133 SS&C teachers during 1990-93. In total, these teachers were responsible for the learning of 1,976 6th grade students 1,650 7th grade students, and 1,644 8th grade students. Fifty of the teachers were involved with action research project where approximately 20 agreed to continue at least one section of students in typical classrooms where the textbook was used as an organizer for all that was done. This provided us with a sample of students who did not experience the SS&C approach. Over the duration of the study, non-SS&C students included 429 6th grade students, 440 7th grade students, and 451 8th grade students. Information in the six assessment domains was collected

from all participating teachers for the 1990-93 years (at least one section was selected randomly by school counselors where students studied using conventional instructional procedures). The domains defining instructional goals included:

1. Concept domain (mastering basic content constructs);
2. Process domain (learning the skills needed to study the natural universe);
3. Creativity domain (suggested causes, predicted consequences, improving quantity and quality of questions, explanations, and test for the validity of personally generated explanations);
4. Attitudinal domain (developing more positive feelings concerning the usefulness of science, science/social studies classes, science/social studies teachers, and science/social science careers);
5. Applications and connections domain (using concepts and processes in new situations); and
6. World view domain (formulating an accurate picture of the nature of science and technology).

Instruments and Assessment

Instruments and procedures for assessing in all six domains include the following:

The Concept Domain was assessed by multiple choice tests with test-retest (one week later) reliability ranging from 0.76 to 0.81. Many of these tests were available from the textbook publishers that the teacher had used previously. Sample item: Which of the following would most likely cause tooth decay by overeating? A) Carrot; B) Candy; C) Bread; D) Hamburger.

The Process Domain was represented by 13 skills identified by the American Association for the Advancement of Science (AAAS) including: observing, using space-time relationships, classifying, graphing and organizing, using numbers, measuring, communicating, inferring, formulating hypotheses, predicting, interpreting data, controlling variables, defining operationally, and experimenting. The test-retest (one week later) reliabilities of the process tests used in this study ranged between 0.82 to 0.90. Sample item: Which variable should be held constant in an experiment which measures the effect of exercise on the rate of respiration? A) The temperature of

the environment; B) The body temperature of the subject; C) The carbon dioxide concentration in the environment; D) The carbon dioxide concentration in the blood of the subject.

The Application Domain was tested by multiple choice items focusing on possible uses of knowledge and skills in everyday life. Some dimensions of application include: solving everyday problems, understanding science and technological principles related to everyday life, maintaining critical attitude related to advertising and commercials, and becoming involved in community action. Because of the different contexts, each teacher used unique application items. The test-retest reliabilities ranged from 0.79 to 0.83 with retests administered one week later. The sample items illustrates the nature of application items related to specific concepts of science: Which of the following is the main reason that water should not be stored in the freezer in a totally filled glass container? A) The taste of the water will change; B) The glass container will break; C) The water reacts with glass in very low temperatures; D) Lack of space will prevent the water from freezing.

The Creativity Domain is based on visualizing and imagining, combining ideas and objects in new was, identifying unique uses for certain objects, and diverging. Basic creativity skills studied include student ability to question, to suggest explanations, and to predict consequences. The average reliability for scoring the results by the teachers was 0.88 with retests given one week later. Essentially, a discrepant event is described; students are asked to offer questions prompted by the situation, to offer explanations, and suggest consequences. Scores tabulate the quantity of responses in each category and then the responses are rated as to pertinence and uniqueness. Questions in the creativity domain include:

1. Describe what would happen in a world without gravity. Write down as many response as you can which you believe are correct. Be as imaginative as you can.
2. In a visit to the zoo you stop to observe an elephant. Write down as many questions as you can for which you may find answers by observing the elephant.

The Attitude Domain was assessed in all the classes by an 18 item Likert-type, five point scale incorporating items from the National Assessment of Educational Progress, Third

Assessment of Science (1978). The test-retest reliability was 0.82 with tests administered one week apart. A sample item from the program manual reads "Being a scientist would be fun" (Yager, Blunck & Ajam, 1990).

The World View Domain was assessed with a Likert-Scale. The items included were taken from several instruments used to study student learning about the nature of science, namely TOUS (Cooley & Klopfer, 1961) and VOSTS (Aikenhead, 1987). The instrument was judged as valid by a panel of philosophers of science. Reliability by test-retest was established as 0.88 to 0.93. Sample items: Science is an attempt to know more about the world around us; and Science deals with activities that affect people's lives at home, in school, and in society.

Due to the use of multiple schools, a variety of lessons, and students of different ages, different items had to be used by different teachers for assessing students in the concept and application domains. Standard instruments and items were used in the other four domains. However, all six domains were assessed in each class with pre- and post-measures. The specific instruments were taken from the *Iowa Assessment Package* (McComas & Yager, 1988; Yager, Blunck & Ajam, 1990, Yager, Kellerman & Blunck, 1992). In many cases, chapter and unit tests provided by national curriculum groups served as instruments in the concept domain. It was recognized that this could have given preference to students in non-SS&C sections. In many cases, teachers prepared an application item to correspond directly with each concept item.

The pretesting of students was completed in September of the new academic year by the participating teachers each of the 1990-93 years. Posttesting of students was completed in a similar manner early in June. All pre- and posttests were administered by the school counselors or other school personnel to assure that teachers did not inadvertently favor one group of students.

Results and Interpretations

Tables 1 through 4 indicate the results of SS&C reform in Iowa schools involving 133 6th, 7th, and 8th grade teachers. Table 1 indicates changes in teacher confidence to teach with an issue-oriented focus. The 133 SS&C teachers are compared with 48 teachers who had been involved with another inservice program in Iowa but were not participants in Iowa-SS&C. The results

indicate a significant increase in teacher confidence (at the 0.01 confidence level) favoring SS&C teachers.

Table 1

Changes in Teacher Confidence to Teach SS&C, 1990-93

Grade Level	SS&C Group N	Posttest Mean	Posttest S.D.	Pretest Mean	Pretest S.D.	Non-SS&C Group N	Posttest Mean	Posttest S.D.	Pretest Mean	Pretest S.D.	F
6	48	33.9	3.0	19.3	1.9	20	21.4	2.3	19.6	2.0	120.6*
7	43	34.5	2.8	18.9	1.8	16	20.5	2.1	18.7	1.9	119.3*
8	42	35.1	2.8	20.1	1.9	12	21.3	2.0	19.3	1.9	100.4*
6-8	133	34.4	2.9	19.5	1.9	48	21.0	2.1	19.2	1.9	117.3*

* Analyses of Variance with Repeated Measures were used to compute the results that were all significant at the confidence level 0.01

Table 2 reports on changes in teaching procedures for the 133 SS&C teachers with the pre-assessment occurring before SS&C summer workshops and SS&C teaching the following year. The post-assessment was accomplished after one full year of SS&C teaching in June. Five procedures were observed where a rubric was constructed to assess the degree that teachers met the procedures required for SS&C. The procedures include:

1. modeling process skills procedures with students;
2. planning lessons;
3. matching goals with curriculum and instruction;
4. assessing students success with basic concept mastery; and
5. involving students actively in learning.

It can be seen that SS&C teachers exhibit the behaviors significantly better than do the non-SS&C teachers (significance at the 0.01 level of confidence).

Table 2

Differences Between SS&C and Non-SS&C Teachers as Revealed by Observation of Classroom and Video Recording of a Sample of Twelve Lessons

Teaching Procedure	SS&C (N = 133) Mean[a] Pre	SS&C (N = 133) Mean[a] Post	SS&C (N = 133) S.D. Pre	SS&C (N = 133) S.D. Post	Non-SS&C (N = 48) Mean[a] Pre	Non-SS&C (N = 48) Mean[a] Post	Non-SS&C (N = 48) S.D. Pre	Non-SS&C (N = 48) S.D. Post	F
1. Modeling process skills procedures with students	2.73	3.85	0.70	0.67	2.78	3.03	0.61	0.55	29.7*
2. Planning lessons	3.04	4.07	0.64	0.71	3.08	3.20	0.67	0.68	26.2*
3. Matching goals with curriculum and instruction	3.35	4.11	0.71	0.76	3.31	3.45	0.68	0.70	21.5*
4. Assessing student success with basic concept mastery	3.21	4.07	0.65	0.67	3.24	3.30	0.66	0.69	23.8*
5. Involve students actively in learning	3.05	4.32	0.71	0.82	3.08	3.21	0.65	0.63	28.7*

a Higher mean scores indicate more positive results.
* F-values are significant at the confidence level of 0.05 based on the Analyses of Covariance (ANCOVA) with the pretest scores as the covariate.

Table 3 includes data provided by teachers concerning the central role of students in the classroom. The ten items are a part of a constructivist learning inventory that SS&C teachers are asked to use throughout a given year as they move to SS&C teaching. The data reveal that teachers do change positively in terms of utilizing procedures (mostly use of students) as they move to more consistent use of constructivist teaching practices.

Table 3

Teacher Use of Constructivist Practices by Iowa Teachers Prior to SS&C Teaching at the End of One Year with Iowa SS&C Reform

		Pre[a]		Post (N = 125)		
		Mean[b]	S.D.	Mean[b]	S.D.	T
Student...						
1.	identified the social issue	2.45	0.60	3.36	0.72	22.1*
2.	sees issues as relevant	3.22	0.82	4.01	0.87	17.8*
3.	asks the questions	2.92	0.67	3.85	0.82	19.6*
4.	identified written and human resources	2.46	0.51	3.71	0.74	25.7*
5.	locates written resources	2.74	0.63	3.84	0.71	23.8*
6.	contacts needed human resources	2.39	0.41	3.76	0.62	26.9*
7.	plans investigations and other resources	2.57	0.53	3.76	0.69	25.1*
8.	is able to evaluate himself/herself	3.05	0.63	4.10	0.72	23.3*
9.	can apply new concepts and process skills to new situations	2.96	0.62	3.87	0.73	18.4*
10.	takes action(s) for problem-solving	3.21	0.65	3.94	0.73	16.9*

a Sources were not available for eight teachers who provided student data.
b Higher mean scores indicate more positive results.
* T-values are significant at the confidence level of 0.05 based on one-tailed t-tests.

Table 4 is a report of observable teaching behaviors revealed by careful study of 15 video recordings of SS&C classrooms and 15 from non-SS&C classrooms. The videos chosen for review were from the samples provided by the 133 SS&C teachers (those teaching only SS&C classrooms and those teaching both SS&C and traditional classrooms). It can be seen in Table 4 that SS&C teachers were found to exhibit many more traits that characterize SS&C instruction. Again, the issue-oriented study is found to be significantly superior relevant to teaching practice than the situation found in non-SS&C classrooms.

Table 4

Differences of Teaching Behaviors Exhibited by a Random Sampling of Videotapes[a] Recorded in SS&C and Non-SS&C Settings

Behavior Descriptor	MEAN		S.D.		T-value
	Non-SS&C	SS&C	Non-SS&C	SS&C	
Number of teacher questions raised	4.5	15.4	0.8	1.8	26.7*
Time spent dispensing information	18.9	6.1	3.5	1.3	15.8*
Time spent in front of classroom	36.7	15.9	3.2	2.0	21.9*
Time spent with individual students or small groups of students	5.9	32.4	2.6	5.3	23.1*
Number of student questions used to affect instruction	0.8	14.9	0.3	3.1	14.8*
Time spent using student questions for instruction	3.6	27.5	1.8	3.4	29.4*

a A total of 30 videotapes (15 of each for SS&C and non-SS&C settings) were randomly selected for analysis.

* T-values are significant at the confidence level of 0.05 based on one-tailed t-tests.

Tables 5 through 10 provide data showing differences between SS&C and non-SS&C students in 6th, 7th, and 8th grade classrooms in Iowa. In addition to 50 SS&C teachers who voluntarily conduct action research to study the impact of SS&C settings on students' learning, a total of 20 our of these 50 teachers also agreed to select one class to set up as a non-SS&C setting (control group) for this study.

Table 5 reports the situation where 1,976 6th grade students are compared with 429 6th grade students in the realm of the retention of concepts. (In addition, 1,650 7th grade and 1,644 8th grade SS&C students performance was compared with 440 and 451 7th and 8th graders in non-SS&C classrooms.) The data reveal that the students of SS&C classrooms have a significant advantage over students of non-SS&C classrooms in concept mastery as measured by the retention of scientific concepts, principles and theories.

Table 5

Results of Analyses of Covariance (ANCOVA) by Comparing Student Posttest Scores in the Concept Domain in SS&C and Non-SS&C Classes With the Pretest Scores Used as the Covariate

Grade	SS&C Group			Non-SS&C Group			
	N	Mean*	S.D.	N	Mean*	S.D.	F
6	1,976	72.3	18.3	429	49.6	14.8	89.7**
7	1,650	73.4	19.2	440	49.3	15.3	92.3**
8	1,644	72.8	17.9	451	50.3	15.2	89.3**

* These are adjusted means computed in percentage with the post hoc multiple comparison tests.

** Significant at the confidence level of 0.01.

The significant results in the concept domain is surprisingly different from the previous studies (Iskandar, 1991; Mackinnu, 1991; Myers, 1988; Yager & Tamir, 1993). The difference may be explained by different study designs used to conduct these studies. In most of the studies, a format of pre- and posttesting to collect the student data connected with a specific teaching unit was the case. In contrast, this SS&C study focused on a year-long teaching sequence. As a result, the posttest is more like a retention test in that there are a variety of concepts studied during a year-long science course. Thus the significant results reported in Table 5 indicate that the Iowa-SS&C program is successful in helping student retain the concepts learned earlier. These may contribute to the Iowa-SS&C program's continued promotion of STS/constructivist learning practices that provide students more opportunities to actively engage in the learning process and construct their own understanding with respect to various situations. Further, concepts and skills are revisited frequently throughout the course—rather than just once in a given chapter of a textbook or a facet of the course of study.

Continuing, Tables 6, 7, 8, 9, and 10 reveal consistently significant advantage for SS&C students over non-SS&C students in terms of understanding of process skills, application of concepts and process skills in new situations, creativity (including questioning, suggesting causes, and predicting consequences), attitude (toward classes, teachers, study, and careers), and the world view domain (including the philosophical, historical, and sociological dimensions of science

and technology). All advantages for the students enrolled in SS&C classes is at the 0.01 level of confidence.

Table 6

Results of Analyses of Covariance (ANCOVA) by Comparing Student Posttest Scores in the Process Skills Domain in SS&C and Non-SS&C Classes With the Pretest Scores Used as the Covariate

Grade	SS&C Group			Non-SS&C Group			
	N	Mean*	S.D.	N	Mean*	S.D.	F
6	1,976	70.8	17.3	429	50.9	16.2	90.1**
7	1,650	72.3	18.3	440	52.4	15.8	82.5**
8	1,644	70.6	17.5	451	52.3	15.3	76.5**

* These are adjusted means computed in percentage with the post hoc multiple comparison tests.

** Significant at the confidence level of 0.01.

Table 7

Results of Analyses of Covariance (ANCOVA) by Comparing Student Posttest Scores in the Application Domain in SS&C and Non-SS&C Classes With the Pretest Scores Used as the Covariate

Grade	SS&C Group			Non-SS&C Group			
	N	Mean*	S.D.	N	Mean*	S.D.	F
6	1,976	73.4	26.9	429	46.8	16.2	82.3**
7	1,650	72.3	18.3	440	52.4	15.8	82.5**
8	1,644	70.6	17.5	451	52.3	15.3	76.5**

* These are adjusted means computed in percentage with the post hoc multiple comparison tests.

** Significant at the confidence level of 0.01.

Table 8

Results of Analyses of Covariance (ANCOVA) by Comparing Student Posttest Scores in the Creativity Domain in SS&C and Non-SS&C Classes With the Pretest Scores Used as the Covariate

Grade	SS&C Group			Non-SS&C Group			
	N	Mean*	S.D.	N	Mean*	S.D.	F
6	1,976	58.9	29.4	429	46.5	15.5	29.4**
7	1,650	57.4	28.3	440	49.1	16.1	30.6**
8	1,644	56.6	27.2	451	52.2	15.8	21.7**

* These are adjusted means computed in percentage with the post hoc multiple comparison tests.

** Significant at the confidence level of 0.01.

Table 9

Results of Analyses of Covariance (ANCOVA) by Comparing Student Posttest Scores in the Attitude Domain in SS&C and Non-SS&C Classes With the Pretest Scores Used as the Covariate

Grade	SS&C Group			Non-SS&C Group			
	N	Mean*	S.D.	N	Mean*	S.D.	F
6	1,976	60.4	16.8	429	50.9	15.9	29.4**
7	1,650	62.1	17.3	440	48.9	16.0	28.3**
8	1,644	59.5	17.0	451	49.3	15.4	20.9**

* These are adjusted means computed in percentage with the post hoc multiple comparison tests.

** Significant at the confidence level of 0.01.

Table 10

Results of Analyses of Covariance (ANCOVA) by Comparing Student Posttest Scores in the World View Domain in SS&C and Non-SS&C Classes With the Pretest Scores Used as the Covariate

Grade	SS&C Group			Non-SS&C Group			
	N	Mean*	S.D.	N	Mean*	S.D.	F
6	1,976	80.2	17.2	429	62.1	14.8	38.9**
7	1,650	83.3	19.3	440	66.3	18.1	45.2**
8	1,644	83.1	20.1	451	67.4	17.4	39.7**

* These are adjusted means computed in percentage with the post hoc multiple comparison tests.

** Significant at the confidence level of 0.01.

When the classes are studied in terms of differences in gender, student ability level, and socioeconomic status, it is striking to note statistically significant advantages for female students as well as average and below average students. The advantages of the SS&C classroom is especially strong for the average and below who are often non-motivated and non-engaged in classrooms where typical instruction is found. This contrast in terms of instruction can be described as follows:

SS&C Classrooms	Traditional Classrooms
Student-centered.	Teacher-centered.
Individualized and personalized, recognizing student diversity.	Group instruction geared for the average student and directed by the organization of the textbook.
Cooperative work on problems and issues.	Some group work, primarily in the laboratory, following textbook directions.
Students are considered important ingredients in instruction, i.e., active partners.	Students seen as recipients of instruction.
Methodology based on current information and research in developmental psychology involving cognitive, affective, experiential, and maturational studies.	Weak psychological basis for instruction in the sciences; behavioristic orientation.
Teachers build on student experiences, assuming that students learn only from their own experiences.	Teachers ignore students in terms of what they might bring to the instructional process; use of information assumed to follow rote learning.

Summary and Generalizations

The evaluation of Iowa-SS&C Program over the 1990-93 period reveals that it successfully responds to the calls for reform and restructuring of middle school programs. Issue-oriented

studies tend to unify the curriculum while providing advantages in terms of learner outcomes. In addition, massive data are available to verify changes in curriculum, teaching, and student learning. These data are available nationally as states, regions, and districts seek real systemic changes—involving all stakeholders in the educational enterprise. The data thus far all ow for specific conclusions regarding the effectiveness of issue-centered studies in social studies, science, and mathematics in middle schools in the state-wide Iowa-SS&C Program. These included:

1. Iowa-SS&C is successful in increasing teacher confidence to teach social studies, science, and mathematics in the middle school, exemplary use of certain teaching procedures, changes in teacher perceptions of various student attributes prior to and following SS&C instruction, and teacher success with action research projects designed to test their ideas about teaching.

2. Students in Iowa-SS&C classrooms grow positively in concept and process skill mastery, application of both in new situations, creativity skills (questioning, identifying causes, predicting consequences), improvement of attitudes toward school study, classes, teachers, and a world view of the nature of the "science" disciplines. And though the superior student growth in the concept domain has not been reported for studies of issue-oriented teaching for one to two months in duration, such mastery (and retention) proves significantly better than the situation found in traditional classrooms. Evidence shows that low ability and female students are especially well served in SS&C classrooms.

Issue-oriented instruction is found to be superior in terms of stimulating changes in teacher confidence to teach, using desirable teaching practices, utilizing students in ways that characterize constructivist teaching, and in changing teaching in observable ways as recorded by video transcripts. It also results in significantly improved student learning in terms of creativity, understanding process skills, applications of process skills and concepts, and the development of positive attitudes for school study, teachers, and related careers. And, importantly, it proves as successful as more traditional approaches in terms of successful learning of basic concepts. For

the special teaches involved in this study, the issue-oriented classrooms were significantly better in producing students who were better in terms of concept mastery.

REFERENCES

Aikenhead, G. S. (1987). *Views on science-technology-society.* Saskatoon, Saskatchewan: University of Saskatchewan.

Cooley, W. W., & Klopfer, L. E. (1961). Test on understanding science (TOUS). Princeton, NJ: Educational Testing Service.

Iskandar, S. M. (1991). *An evaluation of the science-technology-society approach to science teaching.* Unpublished doctoral dissertation, The University of Iowa, Iowa City.

Mackinnu. (1991). *Comparison of learning outcomes between classes taught with a science-technology-society (STS) approach and a textbook oriented approach.* Unpublished doctoral dissertation, University of Iowa, Iowa City.

McComas, W. F., & Yager, R. E. (Eds.). (1988). *The Iowa assessment package for evaluation in five domains of science education.* Iowa City, IA: The University of Iowa, Science Education Center.

Myers, L. H. (1988). *Analysis of student outcomes in ninth grade physical science taught with a science/technology/society focus versus one taught with a textbook orientation.* Unpublished doctoral dissertation, University of Iowa, Iowa City.

National Science Teachers Association. (1990-1991). Science/technology/society: A new effort for providing appropriate science for all (Position Statement). In *NSTA Handbook* (pp. 47-48). Washington, DC: Author.

Yager, R. E. (1991). The constructivist learning model: Towards real reform in science education. *The Science Teacher, 58*(6), 52-57.

Yager, R. E., Blunck, S. M., & Ajam, M. (Eds.). (1990). *The Iowa assessment package for evaluation in five domains of science education (2nd ed.).* Iowa City, IA: The University of Iowa, Science Education Center.

Yager, R. E., Kellerman, L., & Blunck, S. M. (1992). *The Iowa assessment handbook.* Iowa City, IA: The University of Iowa, Science Education Center.

Yager, R. E., & Tamir, P. (1993). STS approach: Reasons, intentions, accomplishments and outcomes. *Science Education*, *77*(6), 637-658.